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FIPS PUB 17-1
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character structure and character parity sense for serial-by-bit data communication in the american national standard code for information interchange

american national standards institute, inc.
1430 broadway, new york, new york 10018

X3.16-1976

This standard has been adopted for Federal Government use.

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ANSI®
X3.16-1976
Revision of
X3.16-1966

American National Standard Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange

Secretariat

Computer and Business Equipment Manufacturers Association

Approved June 25, 1976

American National Standards Institute, Inc

American National Standard

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Foreword

(This Foreword is not a part of American National Standard Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange, X3.16-1976.)

This standard defines character structure for both synchronous and asynchronous transmission modes, since arguments on the nature of character structure are closely related to the method by which transmission is accomplished. The standard applies to general information interchange at the interface between data processing terminal equipment and data communication equipment. It is a revision of American National Standard Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange, X3.16-1966.

This standard is one of a series developed by Task Group X3S3.3 on Data Communication Formats under the coordination of the X3S3 Subcommittee on Data Communications of American National Standards Committee on Computers and Information Processing, X3. Task Group X3S3.3, which was organized late in 1962 and held its first meeting in January 1963, is charged with the responsibility for standardizing character format, data transmission of characters within a hierarchy of groupings (that is, words, blocks, messages, etc) including group error control, and the order or sequence of bits within characters (including parity).

Other standards provide specifications for bit sequencing, formats for parallel-by-bit, serial-by-character data transmission, and other parameters vital to the transmission of information between the types of equipment previously mentioned.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Computers and Information Processing, X3. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the X3 Committee had the following members:

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Contents

American National Standard Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange

1. Scope

1.1 This standard specifies the character structure and sense of character parity for serial-by-bit, serial-by-character synchronous and asynchronous data communication in the American National Standard Code for Information Interchange, X3.4-1968 (ASCII), and the codes invoked when applying the American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange, X3.41-1974.

1.2 This standard applies to general information interchange at the interface between data processing terminal equipment (such as data processors, data media input-output devices, and office machines) and data communication equipment (such as data sets and modems).

2. Synchronous Data Communication

2.1 Seven-Bit Environment

2.1.1 Standard Character Structure. The character structure for synchronous data communication shall consist of 8 bits (7 ASCII bits, b_1 through b_7, plus 1 character parity bit) having equal time intervals. See Fig. 1(a).

2.1.2 Standard Sense of Character Parity. The sense of character parity for synchronous data communication shall be *odd* over the 8 bits (7 ASCII bits and 1 character parity bit), that is, an odd number of "1" (marking) bits per character.

2.2 Eight-Bit Environment

2.2.1 Standard Character Structure. The character structure for synchronous data communication shall consists of 8 bits (a_1 through a_8) having equal time intervals. See Fig. 1(b).

2.2.2 Standard Sense of Character Parity. There is no parity bit in the 8-bit environment.

3. Asynchronous Data Communication

3.1 Seven-Bit Environment

3.1.1 Standard Character Structure. The character structure for asynchronous data communication shall consist of 10 signal elements having equal time intervals: one "0" (spacing) start element, 7 ASCII bits (b_1 through b_7), one character parity bit, and one "1" (marking) stop element. The intercharacter interval (the time interval between the end of a stop element and the beginning of the next start element) may be of any length, and is of the same sense as the stop element, that is, "1" (marking). See Fig. 2(a).

3.1.2 Standard Sense of Character Parity. The sense of character parity for asynchronous data communication shall be *even* over the 8 bits (7 ASCII bits and one character parity bit), that is, an even number of "1" (marking) bits per character.

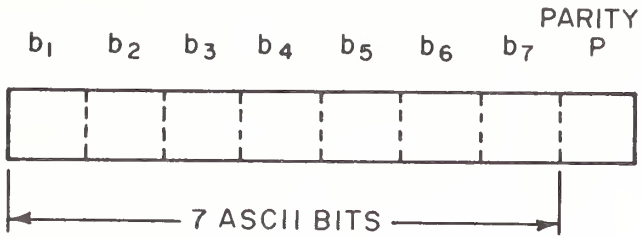
3.2 Eight-Bit Environment

3.2.1 Standard Character Structure. The character structure for asynchronous data communication shall consist of 10 signal elements having equal time intervals: one "0" (spacing) start element, 8 bits (a_1 through a_8), and one "1" (marking) stop element. The intercharacter interval (the time interval between the end of a stop element and the beginning of the next start element) may be of any length, and is of the same sense as the stop element, that is, "1" (marking). See Fig. 2(b).

3.2.2 Standard Sense of Character Parity. There is no parity bit in the 8-bit environment.

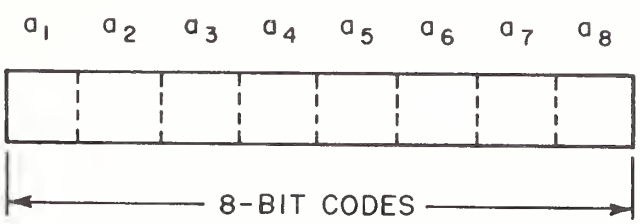
4. Qualifications

4.1 Some configurations of communication facilities



7-Bit Environment

(a)

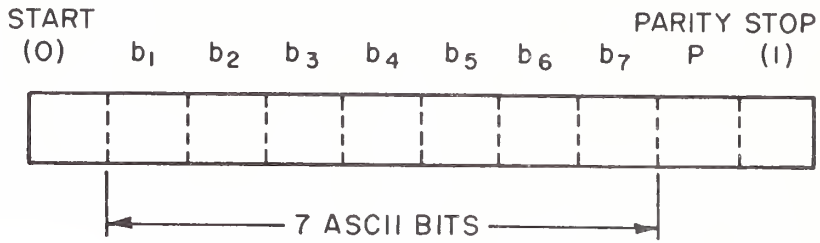


8-Bit Environment

(b)

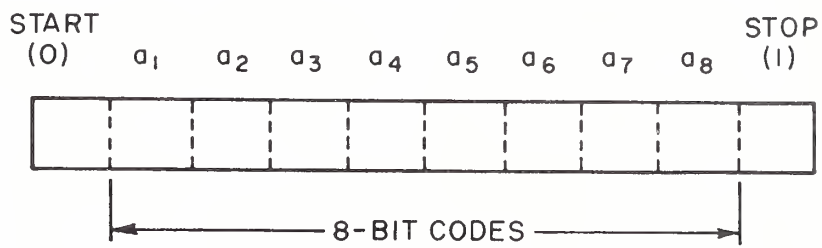
NOTE: The order of transmission is from left to right.

Fig. 1
Character Structure for Synchronous Data Communication



7-Bit Environment

(a)



8-Bit Environment

(b)

NOTE: The order of transmission is from left to right.

Fig. 2
Character Structure for Asynchronous Data Communication

cannot operate satisfactorily with the stop element specified in the asynchronous character structure (see 3.1.1 and 3.2.1). Where this is the case, it is recognized that a stop element of two time intervals is necessary. This exception to character structure is intended to provide relief where character regenerators are employed (as on long-haul, multistation networks), and its use requires prior agreement.

4.2 Receiving equipment must be capable of operation with no intercharacter interval.

4.3 This standard does not specify the bit sequence, the bit rate, or the character rate, nor does it apply to parallel-by-bit, serial-by-character data communication.

5. Revision of American National Standards Referred to in This Document

When the following American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply:

American National Standard Code for Information Interchange, X3.4-1968 (ASCII)

American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange, X3.41-1974

Appendixes

(These Appendixes are not a part of American National Standard Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in American National Standard Code for Information Interchange, X3.16-1976, but are included for information purposes only.)

Appendix A
Criteria

A1. Introduction

A1.1 This Appendix contains the criteria upon which the character structure and the character parity sense were based. Not all criteria have been entirely satisfied. Some of these criteria conflict with others, and the character structure and the character parity sense specified represent accepted compromises of these divergent criteria.

A1.2 The criteria were drawn primarily from communication aspects of information interchange; processing and media recording aspects of information interchange were also considered.

A2. Specific Criteria: Character Structure

NOTE: The following criteria are not mutually consistent and are not listed in order of importance.

A2.1 One hundred twenty-eight characters should be uniquely specified.

A2.2 A single character structure should be specified regardless of the transmission facility, speed, or modulation technique.

A2.3 No ASCII character should require special treatment.

A2.4 The highest possible character rate should be provided.

A2.5 Each character should contain a single character parity bit.

A2.6 Character structure should cause minimum confusion to maintenance and operating personnel.

A2.7 Simple and economic means of error checking should be possible.

A2.8 In asynchronous communication the start and stop signal elements should always be of the same duration as the data bits.

A2.9 In asynchronous communication the character structure should contain one start and one stop signal element.

A2.10 In asynchronous communication the character structure should contain more than one stop signal element.

A3. Specific Criteria: Sense of Character Parity

NOTE: The following criteria are not mutually consistent and are not listed in order of importance.

A3.1 No ASCII character should require special treatment.

A3.2 There should be no restrictions on sequences of characters (for example, Successive Nulls, Syncs, Spaces, Zeros, or Deletes).

A3.3 All characters in the ASCII should have the same parity sense (odd or even).

A3.4 The sense (odd or even) of the character parity bit should minimize hardware complexity.

A3.5 Maximum compatibility should be provided with the parity sense requirements of the various media.

A3.6 The sense of the character parity should be the same regardless of the data transmission technique (for example, synchronous or asynchronous), the transmission facility (for example, bandwidth or distortion), speed, or modulation technique.

A3.7 Equipment complexity should be minimized when alternately handling other 8-bit codes or a binary bit stream.

A3.8 The character parity sense should cause minimum confusion to maintenance and operating personnel.

Appendix B
Design Considerations

B1. Introduction

B1.1 System factors considered in this standard are transmission efficiency, reliability, error control, media requirements, equipment complexity, maintenance confusion, and transition to and from alternate non-ASCII codes or binary bit stream data.

B1.2 A single character structure could not be specified for both asynchronous (start-stop) and synchronous data communication. Therefore two character structures, one for synchronous and one for asynchronous communication, are specified.

B2. Character Structure for Synchronous Data Communication

B2.1 Synchronous data communication can be achieved by transmitting only the 7 information bits for each ASCII character. However, the Null and Delete characters of ASCII would provide no signal element transitions, and successive Null or Delete characters would cause self-clocking synchronous systems to lose synchronization. To overcome this difficulty, either the Null and Delete characters require special handling, or an eighth signal element must be added to each character to assure at least one signal transition within every ASCII character. The latter method was determined to require less equipment complexity and was therefore selected.

B2.2 Two choices were available for the use of the eighth signal element that assures at least one transition per character:

(1) A bit always opposite in value to a specified information bit

(2) An odd character parity bit

The odd character parity bit was selected because it also provides a basic method of error checking.

B2.3 All 7 ASCII bits and the odd character parity bit were specified to be of unit time interval in order to simplify timing equipment in transmitters, receivers, and regenerators.

B3. Character Structure for Asynchronous Data Communication

B3.1 Asynchronous binary data communication requires that synchronization be derived from the signal elements of each character.

B3.2 A straightforward technique for enabling character synchronization is to append a start signal element and a stop signal element to each ASCII character. Although there is no synchronization requirement for signal elements, a single character parity bit is included to permit a simple error check.

B3.3 The start signal element, the 7 ASCII bits, the character parity bit, and the stop signal element are of the same duration to simplify the requirements for timing equipment in transmitters and receivers.

B3.4 Two choices of character parity sense in asynchronous data communication were possible:

(1) *Even character parity sense* permits consistent character parity sense when using perforated tape or edge-punched documents; facilitates the use of the Delete character as a "timing" character in electromechanical control devices; facilitates the use of an arbitrary spacing interval to turn on motors in asynchronous electromechanical devices; and facilitates disconnection of electromechanical line-switched asynchronous terminals upon receipt of a timed spacing interval.

(2) *Odd character parity sense* permits consistent character parity sense for all data transmission; avoids parity sense inversion when interchanging data between synchronous and asynchronous systems; simplifies maintenance techniques and documentation; and facilitates the handling of parity sense in mixed (synchronous and asynchronous) systems.

B3.5 The question of asynchronous character parity sense resolves itself into a choice between two specific alternatives: even parity sense results in more economical punched media electromechanical terminals; odd parity sense is consistent with synchronous data transmission, and results in hardware savings in mixed (synchronous and asynchronous) systems.

The conclusion reached is that the economic advantage of even parity sense in electromechanical asynchronous equipment outweighs the advantage that consistent parity sense provides in mixed data communication systems.

American National Standards on Computers and Information Processing

X3.1-1976 Synchronous Signaling Rates for Data Transmission

X3.2-1970 (R1976) Print Specifications for Magnetic Ink Character Recognition

X3.3-1970 (R1976) Bank Check Specifications for Magnetic Ink Character Recognition

X3.4-1968 Code for Information Interchange

X3.5-1970 Flowchart Symbols and Their Usage in Information Processing

X3.6-1965 (R1973) Perforated Tape Code for Information Interchange

X3.9-1966 FORTRAN

X3.10-1966 Basic FORTRAN

X3.11-1969 Specification for General Purpose Paper Cards for Information Processing

X3.12-1970 Vocabulary for Information Processing

X3.14-1973 Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)

X3.15-1976 Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission

X3.16-1976 Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange

X3.17-1974 Character Set and Print Quality for Optical Character Recognition (OCR-A)

X3.18-1974 One-Inch Perforated Paper Tape for Information Interchange

X3.19-1974 Eleven-Sixteenths-Inch Perforated Paper Tape for Information Interchange

X3.20-1967 (R1974) Take-Up Reels for One-Inch Perforated Tape for Information Interchange

X3.21-1967 Rectangular Holes in Twelve-Row Punched Cards

X3.22-1973 Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)

X3.23-1974 Programming Language COBOL

X3.24-1968 Signal Quality at Interface between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission

X3.25-1976 Character Structure and Character Parity Sense for Parallel-by-Bit Communication in the American National Standard Code for Information Interchange

X3.26-1970 Hollerith Punched Card Code

X3.27-1969 Magnetic Tape Labels for Information Interchange

X3.28-1976 Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links

X3.29-1971 Specifications for Properties of Unpunched Oiled Paper Perforator Tape

X3.30-1971 Representation for Calendar Date and Ordinal Date for Information Interchange

X3.31-1973 Structure for the Identification of the Counties of the United States for Information Interchange

X3.32-1973 Graphic Representation of the Control Characters of American National Standard Code for Information Interchange

X3.34-1972 Interchange Rolls of Perforated Tape for Information Interchange

X3.36-1975 Synchronous High-Speed Data Signaling Rates between Data Terminal Equipment and Data Communication Equipment

X3.37-1974 Programming Language APT

X3.38-1972 Identification of States of the United States (Including the District of Columbia) for Information Interchange

X3.39-1973 Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)

X3.40-1976 Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE)

X3.41-1974 Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange

X3.42-1975 Representation of Numeric Values in Character Strings for Information Interchange

X3.44-1974 Determination of the Performance of Data Communication Systems

X3.45-1974 Character Set for Handprinting

X3.46-1974 Unrecorded Magnetic Six-Disk Pack (General, Physical, and Magnetic Characteristics)

X3.49-1975 Character Set for Optical Character Recognition (OCR-B)

X3.50-1976 Representations for U.S. Customary, SI, and Other Units to Be Used in Systems with Limited Character Sets

X3.51-1975 Representations of Universal Time, Local Time Differentials, and United States Time Zone References for Information Interchange

X3.52-1976 Unrecorded Single-Disk Cartridge (Front Loading, 2200 BPI), General, Physical, and Magnetic Requirements

X3.53-1976 Programming Language PL/I

X3.54-1976 Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording)

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